Travis S. Humble

Knoxville, Tennessee USA
Citizenship: United States of America

humblets@ornl.gov
thumble@utk.edu
865-574-6162

Education

Ph.D. Theoretical Chemistry **1998-2005**
University of Oregon, Eugene, OR

B.Sc. Chemistry with University Honors **1994-1998**
University of North Carolina at Wilmington, Wilmington, NC

Professional Experience

Director, Quantum Computing Institute **2012-now**
Oak Ridge National Laboratory

- Prioritize quantum computing research portfolio
- Lead technical programs and research personnel
- Engage with internal and external stakeholders

Associate Professor, Bredesen Center **2013-now**
University of Tennessee

- Faculty with the Bredesen Center for Interdiscplinary Graduate Studies
- Teach undergraduate, graduate, and postdoctoral students
- Research high performance computing for energy sciences

Scientist, Computer Science and Mathematics Division **2007-now**
Oak Ridge National Laboratory

Intelligence Community Postdoctoral Research Fellow **2005-2007**
Oak Ridge National Laboratory

Professional Activities

Professional Societies

SPIE (senior member), IEEE (senior member, Signal Processing, Communication Societies) APS (member), AAAS (member)

Recent Program Committees

DOE Quantum Computing Workshop (2015), ORNL Quantum Computing Materials and Interfaces (2015), IARPA Quantum Noise and Model Reduction Workshop (2015), ICQNM (2016), IEEE P1913 Standards Committee for Software-defined Quantum Networking (2016)

Journal Reviewer:

Physical Review Letters, Physical Review A, Journal of Physics A, Physica Scripta, Applied Physics Letters, Journal of Defense Modeling & Simulation, IEEE Journal of Quantum Electronics, European Physics Letters, New Journal of Physics, Frontiers in Physics, Quantum Information Processing

Recent Invited Presentations

- Beyond CMOS, "Software Ecosystems for Quantum Computing" (April 2016) *invited*
- Army Research Laboratory, "Programmable Quantum Networks" (March 2016) *invited*
- Computer Science and Mathematics Division, Oak Ridge National Laboratory, "Quantum Computing Systems and Software," (January 2016), *invited*
- Smoky Mountains Computational Sciences and Engineering Conference, "Quantum Computing for Science and Engineering," (September 2015), *invited, best poster*
- Workshop on Quantum Computing Materials and Interfaces, "Hybrid HPC Systems and Programs," (August 2015), *invited*
- Workshop on Quantum Repeaters and Networks, "Software-defined quantum networks," (May 2015), *invited*
- IARPA Quantum Simulation Workshop, "Renormalization Group Theory for Quantum Circuit Reduction," (April 2015), *invited*
- Army Research Laboratory Computational Sciences Campaign Meeting, "ORNL Quantum Computing Institute," (March 2015), *invited*
- Naval Research Laboratory Collaboration Meeting, "Associative Memory Recall using Adiabatic Quantum Optimization," (November 2014), *invited*
- North Carolina State University Computer Science Colloquium, "Quantum Computing Systems and Software", (October 2014), *invited*
- SPIE Quantum Information and Quantum Computation XI, "Quantum Statistical Testing of a Quantum Random Number Generator", (August 2014), *invited*

Student Mentoring

• Jed Storey	2008-2009	High School Senior, Oak Ridge High School
• Clint Holman	2008	Undergraduate, Middle Tennessee State University
• Pramita Mitra	2009	Graduate Student, University of Notre Dame
• Chrisqueria Bragg	2009	High School Junior, Tennessee Governor's Academy
• Jessica Droke	2009-2010	High School Junior, Tennessee Governor's Academy
• Brian Williams	2010-2014	Graduate Student, University of Tennessee
• Alex McCaskey	2010-2012	Graduate Student, Virginia Tech
• Hadayat Seddiqi	2011-2015	Undergraduate, Georgia Southern University
• Christine Klymko	2011	Graduate Student, Emory University
• Ali Ismail	2011	Undergraduate, Penn State Behrend
• Justin Kidder	2011	High School Sophomore, Oak Ridge High School
• Allen Bishop	2011-2013	Postdoctoral Researcher, Oak Ridge National Laboratory
• Keith Britt	2011-Current	Graduate Student, University of Tennessee
• Ron Sadlier	2013-Current	Undergraduate, University of Rhode Island
• Rebekah Herrman	2013-2014	Undergraduate, Christian Brothers University

- Allison Sachs 2014 Undergraduate, University of Tennessee
- Erica Grant 2014-Current Undergraduate, Virginia Tech
- Elizabeth Piersall 2014-2015 Undergraduate, Virginia Tech
- James Mishra 2014-2015 Undergraduate, University of Minnesota
- Timothy Goodrich 2015-Current Graduate Student, North Carolina State University
- Eugene Dumitrescu 2015-Current Postdoctoral Fellow, University of Tennessee
- Brian Williams 2015-Current Postdoctoral Fellow, ORNL
- Megan Lilly 2015-Current Undergraduate, Virginia Tech
- Anthony Lanzillotta 2015-Current Undergraduate, Virginia Tech
- Ryan Prout 2015-Current Undergraduate, University of Tennessee
- Kathleen Hamilton 2016-Current Postdoctoral Fellow, ORNL
- Fahd Mohiyaddin 2016-Current Postdoctoral Fellow, ORNL

Honors and Awards

2016 Department of Energy Early Career Research Award : Accelerating Applications of High-Performance Computing with Quantum Processing Units

2016 Intelligence Advanced Research Projects Activity : Studies in Quantum Science 2

2016 CNMS Nanoscience Research Award : Support for a Virtual Testbed for Silicon Donor Qubits

2016 NASA Allocation Award: Experimental Studies of Adiabatic Quantum Programming

2015 US Patent Award #9,172,698 System and Method for Key Generation in Security Tokens

2015 ORNL Research Award : Virtual Testbed for Silicon Donor Qubits

2015 ORNL Research Award : Positioning and Characterization of Single Dopants

2015 ORNL Research Award : Systematic Characterization of Quantum Computing Devices

2015 Intelligence Advanced Research Projects Activity Award : Technical Evaluation of Quantum Computing Technologies

2015 Army Research Laboratory Award : Software-defined Quantum Metadata Transport

2015 Promotion to IEEE Senior Member

2015 Mitre CRADA Award : High-performance Decryption and Decompression Algorithms

2015 ORNL Research Award : Modeling Hybrid Quantum Computing

2015 ORNL Research Award : Training Deep Belief Networks with Quantum Computing

2014 Intelligence Advanced Research Projects Activity Award : Studies in Quantum Science

2014 Department of Defense Award : Split-Execution Computing

2014 Promotion to SPIE Senior Member

2014 Intelligence Community Research Award : Topologically enabled Quantum Sensing Platforms

2014 US Patent Application #14/178,863 Self-correcting Quantum Random Number Generator

2013 ORNL Supplemental Performance Award

2012 ORNL Research Award: Quantum state stabilization for unbiased random number generation

2012 ORNL Research Award: Automated Software Tools for Engineering Quantum Computers

2011 Lockheed Martin Shared Vision: Quantum-enhanced verification and validation of software circuits

2010 Defense Threat Reduction Agency Award: Tamper-indicating quantum-optical sensing

2010 Provisional US Patent Application #61/346,148: Quantum spread spectrum communication

2010 ORNL Significant Event Award: Development of a bright single-mode entangled photon source

2010 ORNL Research Award: Quantum Imaging by Compressive Sampling
2010 ORNL Research Award: Quantum Lightwave Circuits
2009 ORNL Significant Event Award: Low-power compact computing platform
2009 ORNL Research Award: WDM Quantum Communication Network
2009 US Patent Award #12/424,957: Tampering detection system using quantum-mechanical systems
2008 Department of Energy Office of Science Award: Outstanding mentor for REU students
2008 ORNL Research Award: Multi-Photon Entangled States for QIS
2008 ORNL In Lieu of Merit Award: Exceptional performance
2008 Defense Research Advanced Project Agency Award: Quantum sensing for perimeter protection
2005-2007 Intelligence Community Postdoctoral Research Fellowship
2004 Scholarship from Western Spectroscopy Association
2003 Scholarship from Gordon Research Conference
1998 University and Departmental Honors at UNC-Wilmington
1998 Hypercube Scholar at UNC-Wilmington
1997 Scholarship from Joint Special Operations Command
1996 Scholarship from Ft. Bragg Officer's Wives Club
1994 Honor Scholarship from UNC-Wilmington
1994 North Carolina Honor Scholar
1991 Eagle Scout, Order of the Arrow

All Publications (reverse chronological order)

1. E. Dumitrescu and T. S. Humble, "Multi-qubit correlated and entangling channel discrimination" (in preparation 2016).
2. K. Hamilton and T. S. Humble, "Maximal minor embedding in biparatite graphs" (in preparation 2016)
3. R. S. Bennink, E. M. Ferragut, J. A. Laska, R. C. Pooser, J. F. Nutaro, M. G. Pleszkoch, and T. S. Humble, "Unbiased Monte Carlo Simulation of Near-Clifford Quantum Circuits," (in preparation 2016)
4. T. S. Humble, M. N. Ericson, J. Jakowski, J. Huang, C. Britton, F. G. Curtis, E. Dumitrescu, F. A. Mohiyaddin, and B. G. Sumpter, "A Computational Design Workflow for Silicon Donor Qubits," (submitted 2016)
5. K. E. Hamilton, A. J. McCaskey, J. Schrock, N. Imam, and T. S. Humble, "Associative Memory Models with Adiabatic Quantum Optimization," ORNL Neuromorphic Computing Workshop (accepted 2016).
6. T. Goodrich, T. S. Humble, and B. D. Sullivan, "Optimizing Adiabatic Quantum Program Compilation using a Graph-Theoretic Framework", SIAM Workshop on Network Science (2016).
7. T. S. Humble, A. J. McCaskey, J. Schrock, K. A. Britt, H. Seddiqi, and N. Imam, "Performance models for split-execution computing," 18th Workshop on Advances in Parallel and Distributed Computational Models, (2016)
8. R. J. Sadlier and T. S. Humble, "Superdense Coding Interleaved with Forward Error Correction," *Quantum Measurements and Metrology* **3**, 1 (2016); cf. arXiv:1601.06321

9. V. R. Dasari and T. S. Humble, "OpenFlow Arbitrated Programmable Network Channels for Managing Quantum Metadata," (submitted 2015); cf. arXiv:1512.08545
10. V. R. Dasari, R. Sadlier, R. Prout, B. Williams, and T. S. Humble, "Programmable Multi-Node Quantum Network Design and Simulation," Quantum Information and Computation IX, Proc. SPIE **9873**, 0B (2016); cf. arXiv:1604.01276
11. K. A. Britt and T. S. Humble, "High-performance computing with quantum processing units," (submitted 2015); cf. arXiv:1511.04386
12. B. P. Williams, K. A. Britt, and T. S. Humble, "A tamper-indicating quantum seal," *Phys. Rev. Appl.* 5, 014001 (2016); selected for APS Physics Focus article; cf. arXiv:1508.05334
13. E. Dumitrescu and T. S. Humble, "Direct characterization of quantum processes with noisy ancilla," *Phys. Rev. A* **92**, 052329 (2015); cf. arXiv:1508.03053
14. T. S. Humble and B. P. Williams, "Tamper-indicating quantum seals," International Nuclear Materials Management 56th Annual Conference Proceedings art. 300 (2015)
15. B. Williams, T. S. Humble, W. P. Grice, "Nonlocal polarization interferometer for entanglement detection," *Phys. Rev. A* **90**, 042121 (2014). *Selected as an Editor's Suggestion.*
16. T. S. Humble, "Quantum Statistical Testing of a Quantum Random Number Generator," *Proc. SPIE* **9225**, 922509 (2014).
17. H. Seddiqi and T. S. Humble, "Adiabatic Quantum Optimization for Associative Memory Recall," *Frontiers in Physics* **2**, 79 (2014), *invited for special issue, ed. Jacob Biamonte*
18. B. P. Williams, W. P. Grice, and T. S. Humble, "Nonlocal polarization interferometer for entanglement detection," *CLEO: Science and Innovations*, JW2A.123 (2014).
19. T. S. Humble and R. J. Sadlier, "Software-defined Quantum Communication Systems," Optical Engineering **53**, 086103 (2014).
20. T. S. Humble, R. S. Bennink, A. J. McCaskey, J. J. Billings, E. F. D'Azevedo, B. D. Sullivan, C. A. Bishop, C. F. Klymko, and H. Seddiqi, "An Integrated Programming and Development Environment for Adiabatic Quantum Optimization", Computational Science and Discovery **7**, 015006 (2014).
21. B. P. Williams, T. S. Humble, and W. P. Grice, "A Balanced Franson Interferometer," CLEO: QELS Fundamental Science QTu1C.3 (2013).
22. C. A. Bishop, R. S. Bennink, T. S. Humble, P. G. Evans, and M. S. Boyd "A Heralded Noiseless Subsystem," (submitted, 2013); arXiv:1303.6701.
23. T. S. Humble and R. D. Sadlier, "Software-defined Quantum Communication Systems", Proc. SPIE **8872**, 29 (2013).
24. T. S. Humble, R. C. Pooser, and K. A. Britt, "Quantum Statistical Testing of a QRNG Algorithm," *2013 IEEE Photonics Society Summer Topical Meeting Series*¸149 (2013).
25. R. C. Pooser, P. G. Evans, T. S. Humble, W. P. Grice, and B. P. Williams, "Self Correcting Quantum Random Number Generators using Tapered Amplifiers," *2013 IEEE Photonics Society Summer Topical Meeting Series*, 147 (2013).
26. T. S. Humble "Quantum Security for the Physical Layer", IEEE Communication Society Magazine **51** (August, 2013).
27. C. A. Bishop, T. S. Humble, R. S. Bennink, and B. P. Williams, "Quantum-Secured Surveillance Based on Mach-Zehnder Interferometry," arxiv:1303:6701 (preprint, 2013).
28. C. Klymko, B. D. Sullivan, and T. S. Humble, "Adiabatic Quantum Programming: Minor Embedding

With Hard Faults," Quantum Information Processing **13**, 709 (2014); arXiv:1210.8395 [quant-ph].

29. W. Grice, D. Earl, P. Evans, D.-S. Guo, T. Humble, E. Martin, and R. Pooser, "Beam Profiler for Single-Photon Applications based on Compressive Sampling Techniques" *Quantum Measurements, Frontiers in Optics/Laser Science XXVIII* (2012).
30. T. S. Humble and F. M. Rudakov, "Standoff Detection of Uranyl Salts," ORNL Report (2012).
31. W. Grice, R. Bennink, P. Evans, T. S. Humble, and J. Schaake, "Auxiliary Entanglement in Photon Pairs for Multi-Photon Entanglement," J. Mod. Opt. **59**, 1538 (2012).
32. R. C. Pooser, D. D. Earl, P. G. Evans, B. Williams, J. Schaake, T. S. Humble ,"FPGA-based gating and logic for multichannel single photon counting," J. Mod. Opt. **59**, 1500 (2012), *invited*
33. W. Grice, D. Earl, P. Evans, D.-S. Guo, T. Humble, E. Martin, and R. Pooser, "Beam Profiler for Single-Photon Applications based on Compressive Sampling Techniques," *Optical Quantum Devices, Quantum Electronics and Laser Science Conference*, QM2H (2012).
34. W. Grice, J. Schaake, and T. Humble, "Four-Photon Polarization-Entangled States with Minimal Spectral and Spatial Entanglement," *Entanglement, Quantum Electronics and Laser Science Conference*, QF3F (2012).
35. R. Pooser, B. Lawrie, D. Earl, T. Humble, and J. Schaake, "Real Time Quantum Imaging via Compressed Sensing," *Symposium on Exploring the Quantum Frontiers of Communications III: Quantum Security & Imaging, CLEO: Applications and Technology*, JTh4K (2012).
36. J. Barhen, T. Humble, P. Mitra, N. Imam, B. Schleck, C. Kotas, and M. Traweek, "Concurrent FFT computing on multicore processors," Concurrency and Computation: Practice and Experiment **24**, 29 (2012).
37. T. S. Humble, "Quantum Spread Spectrum Communication," *Quantum Information and Computation IX*, Proc. SPIE **8057**, 8057J (2011).
38. J. Schaake, R. Bennink, P. Evans, W. Grice, T. Humble, "Bright Photon Pair Source with High Spectral and Spatial Purity," *Quantum Information and Computation IX*, Proc. SPIE **8057**, 8057-02 (2011).
39. W. Grice, R. Bennink, P. Evans, T. Humble, R. Pooser, J. Schaake, and B. Williams, "Time-bin entanglement distribution on a wavelength-division-multiplexed network," *CLEO:2011 - Laser Applications to Photonic Applications, OSA Technical Digest*, JTuA5 (2011).
40. T. S. Humble, "Quantum Spread Spectrum Communication," *Quantum Communication, Theoretical Entanglement, and Cryptography*, BAPS.2011.MAR.A29.5 (2010).
41. P. G. Evans, R. S. Bennink, W. P. Grice, T. S. Humble, and J. Schaake, "Bright source of spectrally uncorrelated polarization-entangled photons with nearly single-mode emission," Phys. Rev. Lett. **105**, 253601 (2010).
42. J. Barhen, T. Humble, P. Mitra, C. Kotas, N. Imam, and B. Schleck, "FFT-based Spatio-Temporal Noise Covariance Matrix Inversion on Hybrid Multicore Processor Systems," Workshop on Hybrid Multi-Core Computing, High Performance Computing Conference (2010).
43. T. S. Humble, R. S. Bennink, and W. P. Grice, "Simultaneous Teleportation of Multiple Single-Photon Degrees of Freedom," J. Mod. Opt. **58**, 288 (2011).
44. W. Grice, R. Bennink, P. Evans, T. Humble, R. Pooser, J. Schaake, and B. Williams, "Strong spectral entanglement in spontaneous parametric down-conversion," Frontiers in Optics (2010).
45. T. S. Humble, "Spectral and Spread Spectral Teleportation," Phys. Rev. A **81**, 062339 (2010).

46. T. S. Humble, P. Mitra, J. Barhen, and B. Scheck, "Real-time spatio-temporal twice-whitening for MIMO energy detectors," CrownCom (2010).
47. J. Barhen, C. Kotas, T. S. Humble, P. Mitra, N. Imam, M. A. Buckner, and M. R. Moore, "High performance FFT on multicore processors," CrownCom (2010).
48. J. Barhen, T. S. Humble, N. Imam, M. Traweek, and J. Polcari, "Vector-sensor array algorithms for advanced multicore processors," J. Underwater Acoustics (2010).
49. T. S. Humble, P. Mitra, J. Barhen, B. Scheck, J. Polcari, and M. Traweek, "Spatio-temporal signal twice-whitening on the hx3100 ultra low-power multicore processor," IEEE OCEANS'10 (2010).N. Imam, J. Barhen, and T. Humble, "Implementation/acceleration of underwater acoustic source localization algorithms on the CELL multi-core processor via vectorization," IEEE OCEANS'10 (2010).
50. T. S. Humble, "Quantum Spread Spectrum Communication," CLEO/QELS Technical Digest, QthI7 (2010).
51. J. Barhen, T. Humble, P. Mitra, and M. Traweek, "Multi-FFT vectorization for the Cell multicore processor," 2010 IEEE/ACM International Conference on Cluster, Cloud, and Grid Computing (CCGRID10) (2010).
52. P. G. Evans, R. S. Bennink, W. P. Grice, T. S. Humble and J. Schaake, "Bright Entangled Photon Source Optimized for Single Mode Emission and Minimum Spectral Entanglement," *Laser Science XXV*, JMA4 (2009).
53. T. S. Humble, R. S. Bennink, W. P. Grice, and I. J. Owens, "Sensing intruders using entanglement: a photonic quantum fence," *Quantum Information and Computation VII* Proc. SPIE **7342**, 73420H (2009).
54. T. S. Humble, R. S. Bennink, W. P. Grice, and I. J. Owens, "Intrusion Detection with Quantum Mechanics: A Photonic Quantum Fence", Proc. 26th Army Science Conference (2009).
55. J. Barhen, T. S. Humble, M. Traweek, "Elimination of corner-turning in FFT-based sonar array beamforming", J. Acoustical Society of America **123**, 3950 (2008).
56. T. Humble, J. Barhen, and M. Traweek, "Transverse vectorization of fast Fourier transforms on multicore architectures," J. Acoustical Society of America **123**, 3747 (2008).
57. T. S. Humble, R. S. Bennink, and W. P. Grice, "Total teleportation of a single-photon state," Proc. SPIE, *Quantum Communications and Quantum Imaging VI* **7092**, 70920V (2008).
58. J. Barhen, T. S. Humble, M. Traweek, "FFT-based sonar array beamforming without corner turning", New Trends for Environmental Monitoring Using Passive Systems, 1 (2008).
59. T. S. Humble and W. P. Grice, "The effects of spectral entanglement on polarization-entanglement swapping and type-II fusion gates," Phys. Rev. A 77, (2008).
60. T. S. Humble and W. P. Grice, "Spectral effects in quantum teleportation," Phys. Rev. A 75, 022307 (2007).
61. T. S. Humble and W. P. Grice, "Adjunct spectral entanglement in entanglement swapping and type-I fusion gates" Conference on Coherence and Quantum Optics, CsuA32 (2007).
62. T. S. Humble and J. A. Cina, "Molecular state reconstruction by nonlinear wave packet interferometry," Phys. Rev. Lett. 93, 060402 (2004).
63. T. S. Humble and J. A. Cina, "Towards the reconstruction of time-dependent vibronic states from nonlinear wavepacket interferometry signals," Bull. Kor. Chem. Soc. 24, 1111 (2003), Erratum 25, 584 (2004).

64. J. A. Cina, D. Kilin, and T. S. Humble, “Wave packet interferometry for short-time electronic energy transfer: Multidimensional optical spectroscopy in the time domain,” J. Chem. Phys. 118, 46 (2003).

65. J. A. Cina and T. S. Humble, “Molecular wavepacket decomposition by nonlinear interferometry,” Bull. Chem. Soc. Jpn 75, 1135 (2002).

66. T. S. Humble, C. J. Halkides, J. D. Keltner, and M. Messina, “A theoretical study of intra-molecular vibrational effects on the fractionation factor in molecules with low-barrier hydrogen bonds,” Chem. Phys. Lett. 289, 90 (1998).